國立臺灣師範大學 101 學年度碩士班招生考試試題

科目：普通物理　　適用系所：科學教育研究所

注意：1.本試題共 2 頁，請依序在答案卷上作答，並標明題號，不必抄題。2.答案必須寫在指定作答區內，否則依規定扣分。

1. One side of the roof of a building slopes up at an angle θ. A student throws a Frisbee onto the roof. It strikes with some speed and does not bounce, but instead slides straight up the incline. The coefficient of kinetic friction between the plastic Frisbee and the roof is μ_k. The distance between the striking point and the peak of the roof is d. (a) If the striking velocity is v_a, the Frisbee would slide up and stop right at the peak of the roof. Please determine the distance d. (b) If the striking velocity is v_b, the Frisbee would slide over the peak of the roof and go into free-fall, following a parabolic trajectory with negligible air resistance. Determine the maximum height the Frisbee reaches above the height of the building.（20 分）

2. Two astronauts, each having a mass M, are ***tightly*** connected by a rope of length d whose mass is negligible. They are isolated in space, orbiting their center of mass at speeds v. Treating the astronauts as particles, calculate (a) the magnitude of the angular momentum of the system and (b) the rotational energy of the system. By pulling on the rope, one of the astronauts shortens the distance between them to $d/2$. (c) What is the new angular momentum of the system? (d) What are the astronauts' new speeds? (e) How much work does the astronaut do in shortening the rope?（20 分）

3. (a) Write down the first law of thermodynamics in differential form and explain its meaning. (b) Consider an ideal gas with an initial volume V_i at temperature T_i undergoes a reversible process such that the gas occupies a volume V_f at temperature T_f in the end. Derive an expression for the change in entropy ΔS of the system. (c) If the idea gas consists of 2 moles diatomic molecules and if $V_f = 3V_i$ and $T_f = 2T_i$, find out the value for $\Delta S/R$ where R is the gas constant.（20 分）

4. A linearly polarized microwave of wavelength 1.50 cm is directed along the positive x axis. The electric field vector has a maximum value of 175 V/m and vibrates in the xy plane. (a) Assume that the magnetic field component of the wave can be written as $B = B_{\max}\sin(kx - \omega t)$, find the values for $B_{\max}$, k, and ω. Also determine in which plane the magnetic field vector vibrates. (b) Calculate the average magnitude of the Poynting vector for this wave. (c) What radiation pressure would this wave exert if it were directed at normal incidence onto a

perfectly reflecting sheet? (d) What acceleration would be imparted to a 500-g sheet (perfectly reflecting and at normal incidence) with dimensions of 1.00 m×0.750 m? You may need the following physical constants: Permittivity constant $\varepsilon_0 = 8.85 \times 10^{-12} \mathrm{C}^2/\mathrm{N \cdot m}^2$, and Permeability constant $\mu_0 = 1.26 \times 10^{-6} \mathrm{T \cdot m/A}$. （20 分）

5. Two large, parallel metal plates are oriented horizontally and separated by a distance $3d$. A grounded conducting wire joins them, and initially each plate carries no charge. Now a third identical plate carrying charge Q is inserted between the two plates, parallel to them and located a distance d from the upper plate, as shown in the figure below. Let A represent the area of each plate. (a) What induced charge appears on each of the two original plates? (b) What potential difference appears between the middle plate and each of the other plates? （20 分）